WHAT IS CLAIMED IS:

1. A reaction mixture for producing a product saccharide, wherein the reaction mixture comprises an acceptor saccharide and a first type of plant or microorganism cell that produces: a) a nucleotide sugar, and b) a first recombinant glycosyltransferase that catalyzes the transfer of a sugar from the nucleotide sugar to the acceptor saccharide to form the product saccharide.

2. The reaction mixture of claim **1**, wherein the cells are selected from one or more of the group consisting of bacterial cells, yeast cells, fungal cells, and plant cells.

3. The reaction mixture of claim **1**, wherein the cells are permeabilized or otherwise disrupted.

4. The reaction mixture of claim **1**, wherein the glycosyltransferase is a fucosyltransferase and the nucleotide sugar is GDP-fucose.

5. The reaction mixture of claim **1**, wherein the glycosyltransferase is a sialyltransferase and the nucleotide sugar is CMP-sialic acid

6. The reaction mixture of claim **1**, wherein nucleotide sugar is selected from the group consisting of UDP-Gal, UDP-Glc, UDP-Glucuronic acid, UDP-GalNAc, UDP-Galacturonic acid, GDP-mannose.

7. The reaction mixture of claim **1**, wherein the first type of cell produces the nucleotide sugar at an elevated level compared to a wild-type cell.

8. The reaction mixture of claim **7**, wherein the elevated level of the nucleotide sugar results from a deficiency in the ability of the cell to incorporate the nucleotide sugar into a polysaccharide normally produced by the cell.

9. The reaction mixture of claim **7**, wherein the elevated level of the nucleotide sugar is at least 10% higher than the level of the nucleotide sugar produced by the wild-type cell.

10. The reaction mixture of claim **9**, wherein the elevated level of the nucleotide sugar is at least 25% higher than the level of the nucleotide sugar produced by the wild-type cell.

11. The reaction mixture of claim **1**, wherein the nucleotide sugar is synthesized by an enzymatic pathway that includes one or more enzymes that are expressed from heterologous genes.

12. The reaction mixture of claim **11**, wherein the recombinant glycosyltransferase is a sialyltransferase, the nucleotide sugar is CMP-sialic acid and the heterologous gene encodes CMP-sialic acid synthetase.

13. The reaction mixture of claim **12**, wherein the acceptor saccharide is lactose and the product saccharide is sialyllactose.

14. The reaction mixture of claim **11**, wherein the recombinant glycosyltransferase is a β1,4-GalNAc transferase and the nucleotide sugar is UDP-GalNAc.

15. The reaction mixture of claim **14**, wherein the acceptor is lactose and the product saccharide is β1,4-GalNAc-lactose.

16. The reaction mixture of claim **11**, wherein the recombinant glycosyltransferase is a galactosyltransferase and the nucleotide sugar is UDP-Gal.

17. The reaction mixture of claim **16**, wherein the galactosyltransferase is an α1.3-galactosyltransferase and the product saccharide contains a terminal α1,3-linked galactose residue.

18. The reaction mixture of claim **11**, wherein the enzymatic pathway comprises a full or partial sugar nucleotide regeneration cycle.

19. The reaction mixture of claim **18**, wherein the nucleotide sugar is UDP-GalNAc and the sugar nucleotide regeneration cycle comprises a set of enzymes selected from the group consisting of:

UDP-GalNAc epimerase, UDP-GlcNAc pyrophosphorylase, GlcNAc-1-kinase, polyphosphate kinase and pyruvate kinase; and

UDP-GalNAc pyrophosphorylase, GlcNAc-1-kinase, polyphosphate kinase and pyruvate kinase.

20. The reaction mixture of claim **19**, wherein the reaction mixture further comprises a second cell type that produces a nucleotide that is used as a substrate for the sugar nucleotide regeneration cycle.

21. The reaction mixture of claim **20**, wherein the second cell type comprises an exogenous gene that encodes a nucleotide synthetase polypeptide that catalyzes the synthesis of the nucleotide.

22. The reaction mixture of claim **21**, wherein the first cell type comprises exogenous genes that encode a) a fusion protein that comprises a polypeptide having 3'-sialyltransferase activity and a polypeptide that has CMP-sialic acid synthetase activity; and b) enzymes that catalyze the synthesis of sialic acid from GlcNAc;

and the second cell type comprises an exogenous gene that encodes CMP-synthetase.

23. The reaction mixture of claim **21**, wherein the first cell type is *E. coli* and the second cell type is yeast or *Corynebacterium*.

24. The reaction mixture of claim **1**, wherein the first type of cell produces a second recombinant glycosyltransferase that catalyzes the transfer of a sugar from the nucleotide sugar to the product saccharide to form a further glycosylated product saccharide.

25. The reaction mixture of claim **24**, wherein the nucleotide sugar is UDP-Gal, the first recombinant glycosyltransferase is an β1,4-galactosyltransferase and the second recombinant glycosyltransferase is an α1,3-galactosyltransferase.

26. The reaction mixture of claim **25**, wherein the acceptor saccharide is Glc(R)β-O-R^1, wherein R^1 is -$(CH_2)_n$-COX; X is selected from the group consisting of OH, OR^2, -$NHNH_2$, R is OH or NAc; R^2 is a hydrogen, a saccharide, an oligosaccharide or an aglycon group having at least one carbon atom, and n is an integer from 2 to 18.

27. The reaction mixture of claim **25**, wherein the UDP-Gal is generated by enzymes that are expressed from exogenous genes that encode UDP-Gal 4' epimerase and UDP-Glc pyrophosphorylase.

28. The reaction mixture of claim **1**, wherein the cell further comprises: a) an enzymatic system for producing at least a second nucleotide sugar, and b) at least a second recombinant glycosyltransferase that catalyzes transfer of a sugar from the second nucleotide sugar to the product sugar.

29. The reaction mixture of claim **28**, wherein:

the first recombinant glycosyltransferase is a GlcNAc transferase and the first nucleotide sugar is UDP-GlcNAc; and

the second recombinant glycosyltransferase is a galactosyltransferase and the second nucleotide sugar is UDP-galactose.

30. The reaction mixture of claim **29**, wherein the reaction mixture forms lacto-N-neotetraose (LNnT).

31. The reaction mixture of claim **1**, wherein the reaction mixture also comprises at least a second type of cell that produces a) a second nucleotide sugar, and b) a second recombinant glycosyltransferase that catalyzes the transfer of the sugar from the second nucleotide sugar to the product saccharide.

32. The reaction mixture of claim **31**, wherein the first glycosyltransferase is a galactosyltransferase and the second glycosyltransferase is a GalNAc transferase.

33. The reaction mixture of claim **31**, wherein:

the first cell type comprises a recombinant β1,4-GalNAc transferase, a recombinant β1,4-Gal transferase, UDP-GalNAc and UDP-Gal; and

the second cell type comprises a recombinant α2,3-sialyltransferase and CMP-sialic acid.

34. The reaction mixture of claim **33**, wherein the CMP-sialic acid is produced from CTP and GlcNAc by an enzymatic system in the second cell type that includes recombinant enzymes CMP-sialic acid synthetase, GlcNAc epimerase, NeuAc aldolase, and CMP-synthetase.

35. The reaction mixture of claim **33**, wherein the acceptor saccharide is lactosylceramide or lyso-lactosylceramide and the product saccharide is ganglioside GM_2.

36. The reaction mixture of claim **33**, wherein the second cell type further comprises a recombinant α2,8-sialyltransferase.

37. The reaction mixture of claim **36**, wherein the acceptor is lactosylceramide or lyso-lactosylceramide and the product saccharide is GD_2.

38. The reaction mixture of claim **1**, wherein the reaction mixture also comprises a second type of cell that produces a nucleotide from which is synthesized the nucleotide sugar produced by the first type of cell.

39. The reaction mixture of claim **38**, wherein nucleotide produced by the second cell type and the corresponding nucleotide sugar are selected from the group consisting of:

UTP: UDP-Gal, UDP-GalNAc, UDP-GlcNAc, UDP-Glc, UDP-glucuronic acid, or UDP-galacturonic acid;

GTP: GDP-Fuc; and

CTP: CMP-sialic acid.

40. A cell that produces a product saccharide, wherein the cell comprises:

a) a recombinant gene that encodes a glycosyltransferase;

b) an enzymatic system for forming a nucleotide sugar that is a substrate for the glycosyltransferase; and

c) an exogenous saccharide acceptor moiety;

wherein the glycosyltransferase catalyzes the transfer of a sugar from the nucleotide sugar to the acceptor moiety to produce the product saccharide.

41. The cell of claim **40**, wherein the enzymatic system for forming a nucleotide sugar comprises cycle enzymes for regenerating the nucleotide sugar.

42. The cell of claim **40**, wherein the recombinant gene that encodes a glycosyltransferase is a heterologous gene.

43. The cell of claim **40**, wherein the cell forms the nucleotide sugar at an elevated level compared to a wild-type cell.

44. The cell of claim **43**, wherein the elevated level of nucleotide sugar results from a deficiency in the ability of the cell to incorporate the nucleotide sugar into a polysaccharide normally produced by the cell.

45. The cell of claim **44**, wherein the deficiency is due to a reduced level of a polysaccharide glycosyltransferase activity.

46. The cell of claim **40**, wherein the product saccharide is produced at a concentration of at least about 1 mM.

47. The cell of claim **40**, wherein the enzymatic system for forming a nucleotide sugar comprises an enzyme encoded by a heterologous gene.

48. The cell of claim **47**, wherein the enzyme encoded by the heterologous gene is one or more of:

a GDP-mannose dehydratase, a GDP-mannose 3,5-epimerase, and a GDP-mannose 4-reductase;

a UDP-galactose 4' epimerase;

a UDP-GalNAc 4' epimerase;

a CMP-sialic acid synthetase;

a pyrophosphorylase selected from the group consisting of a UDP-Glc pyrophosphorylase, a UDP-Gal pyrophosphorylase, a UDP-GalNAc pyrophosphorylase, a GDP-mannose pyrophosphorylase, and a UDP-GlcNAc pyrophosphorylase;

a kinase selected from the group consisting of myokinase, pyruvate kinase, acetyl kinase, creatine kinase; and

pyruvate decarboxylase.

49. The cell of claim **48**, wherein the nucleotide sugar is GDP-fucose.

50. A cell that produces a sulfated polysaccharide, the cell comprising:

a heterologous gene that encodes a sulfotransferase; and

an enzymatic system that produces PAPS.

51. The cell of claim **50**, wherein the sulfated polysaccharide is selected from the group consisting of heparin sulfate and carragenin.

52. The cell of claim **50**, wherein the enzymatic system that produces PAPS comprises one or more enzymes that are expressed from exogenous genes.

53. A method of producing a product saccharide, the method comprising contacting a microorganism or plant cell with an acceptor saccharide, wherein the cell comprises:

a) an enzymatic system for forming a nucleotide sugar; and

b) a recombinant glycosyltransferase which catalyzes the transfer of a sugar from the nucleotide sugar to the acceptor saccharide to produce the product saccharide.

54. The method of claim **53**, wherein the glycosyltransferase is encoded by a heterologous gene.

55. The method of claim **53**, wherein the glycosyltransferase is encoded by a gene that is endogenous to the cell and is produced by the cell at an elevated level compared to a wild-type cell.

56. The method of claim **53**, wherein the product saccharide is produced at a concentration of at least about 1 mM.

57. The method of claim **53**, wherein the cell is permeabilized.

58. The method of claim **53**, wherein the cell is an intact cell.

59. The method of claim **53**, wherein the enzymatic system for forming a nucleotide sugar comprises an enzyme that is encoded by a heterologous gene.

60. The method of claim **59**, wherein the enzyme encoded by the heterologous gene is one or more of:

a GDP-mannose dehydratase, a GDP-4-keto-6-deoxy-D-mannose 3,5-epimerase, and a GDP-4-keto-6-deoxy-L-glucose 4-reductase;

a UDP-galactose 4' epimerase;

a UDP-GalNAc 4' epimerase;

a CMP-sialic acid synthetase;

a pyrophosphorylase selected from the group consisting of a UDP-Glc pyrophosphorylase, a UDP-Gal pyrophosphorylase, a UDP-GalNAc pyrophosphorylase, a GDP-mannose pyrophosphorylase, and a UDP-GlcNAc pyrophosphorylase; a kinase selected from the group consisting of myokinase, pyruvate kinase, acetyl kinase, creatine kinase; and

pyruvate decarboxylase.

61. The method of claim **59**, wherein the enzyme for forming a nucleotide sugar and the glycosyltransferase are expressed as a fusion protein.

62. The method of claim **61**, wherein the fusion protein comprises a CMP-sialic acid synthetase activity and a sialyltransferase activity.

63. The method of claim **61**, wherein the fusion protein comprises a galactosyltransferase activity and a UDP-Gal 4' epimerase activity.

64. The method of claim **61**, wherein the fusion protein comprises a GalNAc transferase activity and a UDP-GlcNAc 4' epimerase activity.

65. The method of claim **53**, wherein the nucleotide sugar is GDP-fucose and the glycosyltransferase is a fucosyltransferase.

66. The method of claim **53**, wherein the cell forms the nucleotide sugar at an elevated level compared to a wild-type cell.

67. The method of claim **66**, wherein the elevated level of nucleotide sugar results from a deficiency in the ability of the cell to incorporate the nucleotide sugar into a polysaccharide normally produced by the cell.

68. The method of claim **67**, wherein the deficiency is due to a reduced level of a polysaccharide glycosyltransferase activity.

69. The method of claim **53**, wherein the cell/nucleotide sugar are selected from the group consisting of:

Azotobacter vinelandii/GDP-Man;

Pseudomonas sp./UDP-Glc and GDP-Man;

Rhizobium sp./UDP-Glc, UDP-Gal, GDP-Man;

Erwinia sp./UDP-Gal, UDP-Glc;

Escherichia sp./UDP-GlcNAc, UDP-Gal, CMP-NeuAc, GDP-Fuc;

Klebsiella sp./UDP-Gal, UDP-GlcNAc, UDP-Glc, UDP-GlcNAc;

Hansenula jadinii/ GDP-Man, GDP-Fuc;

Candida famata/UDP-Glc, UDP-Gal, UDP-GlcNAc;

Saccharomyces cerevisiae/UDP-Glc, UDP-Gal, GDP-Man, GDP-GlcNAc; and

X. campesti/UDP-Glc, GDP-Man.

70. The method of claim **53**, wherein the cell is ***Azotobacter vinelandii***, the nucleotide sugar is GDP-mannose, the acceptor saccharide is lactose, the glycosyltransferase is mannosyl transferase, and the product saccharide is mannosyl lactose.

71. The method of claim **53**, wherein the cell is *E. coli*, the nucleotide sugar is CMP-sialic acid, the acceptor saccharide is lactose, the glycosyltransferase is a sialyltransferase, and the product saccharide is sialyllactose.